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"AN ANALYSIS OF A MASSED VERSUS A DISPERSED ATTACKING GROUND FORCE IN CLOSE COMBAT"

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ABSTRACT

A computer simulation of combat is used to compare outcomes of a red tank attack on a blue defense for variations in mass (density) and firepower. Results suggest the defender's need for improvements in fire power to counterbalance the attacker's advantage gained by massing his forces.

"AN ANALYSIS OF A MASSED VERSUS A DISPERSED

ATTACKING GROUND FORCE IN CLOSE COMBAT"

I. PROBLEM

A. Quantification of effect of mass in a simplified dynamic close combat engagement.

A computer simulation is used to model the dynamics of combat to study the importance of the mass of a red force which is attacking a static defending blue force. The attacking (red) force mass was varied by changing the number of tanks in each line and spacing between lines of tanks. Losses of the red and blue forces are compared for each change in mass.

B. Measure effectiveness of changes in defending blue combat capability for conditions of massed red attack.

The base case massed red attack resulted in a favorable outcome for red. Blue's combat power was then increased and results compared. The variations included:

1. Increasing number of blue defenders.

2. Increasing capabilities of direct fire systems.

3. Use of area weapons (Advanced Conventional and Nuclear).

II. BACKGROUND

A. Mass/Dispersal and Time

The concept of mass is central to the basic principles of combat: an attacker should attempt to achieve at least a 3:1 advantage in combat power in a local engagement against a defender in prepared positions. Soviet tactical principles stress the requirement of an attacker to mass quickly and hold force ratios of 5 to 10 over a defender during a breakthrough operation.

Dispersal, the converse of mass, is desirable to decrease vulnerability to massed enemy fire (artillery, air strikes) and area weapons (tactical nuclear, chemical, and advanced conventional munitions).

A critical parameter in combat is time. In a combat situation a commander must carefully time his transition between dispersal and mass as the tactical situation dictates.

B. Combat Modeling to Study Mass

The process of changing mass/dispersal in a dynamic setting and observing the resultant effect on outcome of engagements can be accomplished with a combat model. An interactive, man-in-the-loop, wargame model provides an ability to observe the impact of a large number of complex interrelated parameters (terrain, movement, firepower, and mass) on game results. As in the case with studying the results of a field exercise or of a battle's historic records, it is very difficult in a large simulation model to measure the contribution of mass to the success or failure of a battle. A reason for this difficulty is an inability to hold all other parameters constant as the free parameter, mass in our case, is varied.

When human "commanders" participate in a simulation they will attempt to optimize decisions made as the battle unfolds. Possible runs of luck in the stochastic assessment early in an engagement will affect the range of possible tactical decisions by "commanders". Therefore, a stochastic model presents a variety of possible situations from which decisions are made, albeit the starting conditions and combat missions remain unchanged.

Numerous studies of the tactical battlefield have been conducted at LLNL using a combat simulation model. In these studies, the authors have observed a high degree of correlation between the ability of players to use mass effectively and their resultant success. The war games at LLNL used the JANUS model in an interactive, competitive mode (see Appendix A). Unfortunately, as noted above, it is difficult to isolate in this work the precise relationship between mass and success.

Accordingly, a methodology was devised in which attrition data is collected using a simulation which only models direct fire combat systems defending in prepared positions against lines of attackers with varying distances between lines. It is important to note what is and what is not modeled (see discussion of methodology). This approach attempts to capture that important segment of time in which direct fire systems are engaged in close combat. It does not study the human decision making and tactical maneuver preceding the engagement. This methodology attempts to isolate the relationship between mass and attrition without considering the merit of the tactics which determine mass at the time close combat commences.

C. The JANUS Combat Model

JANUS is an event-driven, stochastic combat model developed by LLNL (See Appendix A) and was used to collect the data in this paper. The model simulates fighting systems, i.e., tanks, as entities. The events modeled along a time line include:

1. Updating position of units on a UTM grid.

2. Achievement and breaking of line-of-sight and acquisition of enemy systems.

3. Direct fire of individual shells.

4. Stochastic assessment of the effects of the shell upon impact.

The system characteristics of the systems modeled are input data to the simulation (see Appendix B).

III. METHODOLOGY

A. Definition of the engagement that was modeled.

A series of simulations were conducted using the JANUS combat model. The forces modeled were task organized as follows:

1. One blue company of ten tanks and four heavy anti-tank weapons (HAWs).

2. One red regiment of 100 tanks.

The missions were:

1. Blue's fighting systems remain in hull down, defensive positions throughout the simulation. The systems engage with enemy units within the maximum range capabilities (2500 meters for tanks, 3700 meters for HAWs) and fire at their maximum rate of fire. Blue tanks were placed in a line perpendicular to red's attack. The HAWs were 500 meters behind the tanks.

2. Red's fighting systems attempt to move directly through blue's defensive positions. Reds forces do not halt or take evasive action. Systems fire at maximum rate of fire and move at assault speed (12 km/hr) when engaging blue.

The starting condition of the simulation placed the red forces 4 km from and moving toward blue's defensive line.

The end condition of the simulation was achieved when all of red or all blue forces were destroyed.

Many of the factors which were not modeled could degrade red's presentation rate (i.e., obstacles, rough terrain, mines, clouds, and dust). Similarly, blue had optimal fields of fire, was dug in, and was not subjected to enemy artillery fire.

B. Constants in the study

The following were constant in this study.

1. Defender frontage - 2 km.
2. Attacker frontage - 1 km.
3. Attack line of departure - 4 km (Initial separation).
4. Opening fire range was at maximum range for each system (2.5 km for tanks and 3.7 km for HAWs).
5. Movement velocity 35 km/hr slowing to an average of 12 km when firing.
6. Unlimited ammunition (for blue).
7. Size of red force was 100 tanks (except as noted).
8. Terrain was absolutely flat.

The characteristics of the systems modeled by the simulation are listed in Appendix B.

C. Description of Parameters Varied in Simulation.

Parameters were varied to measure the sensitivity of mass/dispersal to success in close combat. After the degree of mass required to give the attacker an advantage was established, blue's fire power was increased in an attempt to quantify what was required to offset the advantage of mass. The parameters varied to measure the impact on blue's combat power were: (1) increased number of systems (more tanks and HAWs), (2) increased rate of fire of existing systems, (3) greater red survivability (degraded lethality of blue systems against red tanks) and (4) use of area type weapons on red's massed formation immediately prior to the direct fire engagement.

D. Simulation Parameters

1. Attack Formation Options and the Base Case Simulation.
   The mass/dispersion of red's force was varied by changing red's formation of attack against the base case force of one blue company and a force ratio of 7:1.

   a. <u>Blue's Combat Power</u>
      One blue company

   b. <u>Red's Formation</u>
      i Massed
         Three echelons of tanks: 40, 40, and 20.
         - Intra-line spacing was 25 meters.
         - Inter-line spacings were varied: 100, 250, 500, and 2000 meters.

      ii Standard (default)
         Five echelons of tanks: 20, 20, 20, 20, and 20.
         - Intra-line spacing was 50 meters.
         - Inter-line spacings were varied: 100, 250, 500, and 2000 meters.

iii Dispersed

Ten echelons of tanks: 10, . . ., 10.

- Intra-line spacing was 100 meters
- Inter-line spacings were varied: 100, 250, 500 and 2000 meters.

2. Increased Blue Forces.

The number of blue's combat power was increased by doubling and tripling blue's fighting systems and the attrition was measured as red's mass and dispersion was varied.

a. Blue Combat Power

Blue's number of defending systems was varied from one to three companies.

b. Red's Formation

i intra-line spacing (distance between tanks within a line) 25 and 50 meters.

ii inter-line spacing (distance between attacking lines of tanks) of 250, 500, 1000, and 2000 meters.

3. Increased Blue Rate of Fire

Blue's combat power was increased by increasing the rate of fire of all blue systems by a factor of two . The outcomes are compared to simulations with two blue companies without an increase in rate of fire.

a. Blue's Combat Power.

i One blue company with rate of fire 2X normal.

ii Two blue companies with normal rate of fire.

b. Red's Formation.

i Red's spacing between tanks was held constant at 25 meters.

ii Red's inter-line spacing was 100, 250, 500, 1000, 1500 and 2000 meters.

4. Improved Red Survivability

Red's survivability was increased, consequently reducing blue's combat power. The probability of kill (PK) of red systems by blue systems was reduced by a factor of two. The outcomes of two companies with reduced PKs are compared to a single company with normal PKs.

a. Blue's Combat Power

i Two blue companies and Probability of Kill 50% of normal.

ii One blue company and Probability of Kill normal.

b. Red's Formation.

i Red's spacing between tanks was held constant at 25 meters.

ii Red's inter-line spacing was 100, 250, 500, 1000 and 2000 meters.

5. Effectiveness of Area Weapons against a massed enemy. The conventional battle was simulated after use of the area weapons with damage radii indicated below and red did not change his formation (mass) after the weapon assessment.

a. Blue's Combat Power.

i Blue used one area weapon against red with:

Radii of Damage: 250 meters and 500 meters

Lethality of Area Weapon 33% and 100%

ii One and two blue companies defending.

b. Red's Formation.

i Intra-line spacing of 25, 50, and 100 meters.

ii Inter-line spacing 100 meters (held constant).

IV. Data

The end conditions of each simulation were recorded. A minimum of ten simulations were run for each chosen combination of parameters. The mean attrition (and 1 standard deviation) of each side, red and blue, is plotted in the accompanying figures. All of the losing side's forces have been attrited at the end condition, therefore, the plots indicate the varying numbers of remaining unattrited forces. Due to the stochastic nature of combat, the standard deviation is larger in battles in which the combat power of red and blue are balanced. In simple terms, when forces are balanced there is greater uncertainty in the outcome.

The data plots presented are:

1. One blue company vs three red formations. Figures 1a, 1b, and 1c.

2. Time duration of combat, one blue company vs three red formations.

3. Massed red vs one, two, and three blue companies. Figures 3a, 3b, and 3c.

4. Dispersed red vs one, two, and three blue companies. Figures 4a, 4b, and 4c.

5. One blue company (2x rate of fire) compared with two blue companies.

6. Two blue companies with 1/2 the probability of kill compared with one company with normal probability of kill.

7. Effectiveness of advanced conventional/nuclear munition against mass.

8. Effectiveness nuclear munition against mass.

V. OBSERVATIONS

A. Attack Formation Options and Mass

The attacking red force, as expected, achieved a marked measurable advantage by using attack formations which increase the mass or density of his lines of forces. The advantage achieved by a given force ratio can be very sensitive to the distance between the attacking lines of forces as they are committed to battle. As seen in Plot 1, the greater dispersal of red's force the greater blue's probability of success. Note in Fig. 1c (a formation with only one red tank company of ten tanks in each line), that as the separation between lines of red companies increases to greater than 500 meters the advantage shifts sharply to blue's favor. Note also in Fig. 1a (where red's formation presents four companies (40 tanks), in the first two lines) that if the local combat power, or force ratio, is substantially in the attacker's favor, increasing the separation between lines of attackers does not turn the advantage to blue's forces.

The time duration of the battle is significantly less in the massed formation than when dispersed. The difference in time between the first and last shot fired in each of the corresponding simulations is shown in Fig. 2. The outcomes were resolved in the range of times 3 to 33 minutes. Blue was successful when the battles were longer than 17 minutes. A typical successful battle for blue lasted more than five times longer than a defeat.

B. Increase in Blue's Numbers to Counter Red Mass.

Figures 3 and 4 show the effect of increasing the numbers of blue defenders to offset the advantage of mass. The number was increased to two and to three blue companies. These comparisons were made against our default massed red formation (Fig. 3) and a dispersed red formation (Fig. 4).

Doubling blue's force turns the advantage to blue's favor, but only in simulations with red's lines separated by greater than 1000 meters (Fig. 3b). If red uses a dispersed formation, doubling blue's force gives blue an advantage, but again, only in simulations with red's lines separated by greater than 500 meters (Fig. 4b).

Only by tripling blue's numbers is blue's advantage maintained regardless of red's mass. Tripling blue's numbers (to 42 systems) results in a force ratio of 2.4:1 in red's favor as compared to our standard (default) force ratio of 7.1:1. Normally, a commander will require a force ratio of at least 3:1 to attempt an offensive action.

C. Increase in Blue's Rate of Fire to Counter Red Mass

The rate of fire of all blue systems (tanks and HAWs) was doubled. This was compared to simulations with double the numbers of blue systems firing at a normal rate of fire.

As seen in Fig. 5, doubling blue's rate of fire does not shift the advantage in blue's favor even though there is a shift in blue's favor with the double number of blue systems. This indicates that an increase in rate of fire is not equivalent to a corresponding increase in the number of forces. The difference lies in the survivability of blue's forces. Blue's survivability is greater in the case with double the number of forces due to red's distribution of fire over 28 rather than 14 blue systems.

D. Increase in Red's Survivability

Red's survivability was varied to measure the sensitivity of lethality of direct fire systems to battle outcomes. A comparison was made between two blue companies with halved probability of kill against red systems and one blue company with normal probability of kill capabilities.

As in the rate of fire example, an increase in the number of blue defending systems improves survivability despite the equivalent in the lethality of the two defending systems. The differences are not as marked as in the previous comparison of examining changes in rate of fire.

E. Area Weapons and Mass

The effect of area type weapons (used against the red force immediately prior to the battle) was measured. Plot #7 shows the results of engagements after the use of area weapons with radii of damage (R_d) of 250 and 500 meters and with lethality of 33% and 100%. (Every third tank or every tank was killed within the radii selected.) Simulations were made with one and two companies. In each case, red was massed (100 meters between lines) but one blue company was successful only when a weapon with 500 meter, radius of damage and 100% lethality was used (Fig. 7d, only four red tanks survive the area weapon). Blue was able to defend with an area weapon with R_d = 250 meters and 100% lethality when blue had two companies, but not with one company.

The plots indicate that using area weapons against massed attackers may not offset the significant tactical advantage of mass achieved by a dense formation. This is again observed in Plot #8 where R_d is 250 meters and 500 meters and lethality is 100% against a formations of 25 meters and of 100 meters between tanks. The red force is able to accept significant losses from area weapons and still decisively win if attacking in mass.

VI. GENERAL OBSERVATIONS AND COMMENTS

The simulations indicated that an attacking force achieves a significant advantage when it is able to present its forces in a massed or dense formation, thereby achieving the highest possible local force ratio over the defending forces upon commencement of close combat. Mass was achieved by the attacker by minimizing the distances between lines of attacking forces.

A single blue company had the possibility of being successful against the 7:1 ratio in only a few of the scenarios modeled:

A. Red was very dispersed and presented only a single line of ten tanks at a time, each line separated by greater than 1000 meters and the battle was extended to greater than 17 minutes (Figures 1 and 2).

B. Red's lines of 20 tanks are separated by greater than 2000 meters.

(Fig. 4a)

In this scenario a bimodal outcome was observed. The battle could favor red or blue.

C. An area weapon with a radius of damage of 500 meters and lethality of 100% (nuclear munition) attrits red's massed formation of 100 meters between lines of tanks.

(Fig. 7d and Fig. 8c)

In summary, to be successful when attacked by a large force, the blue defender must limit the presentation rate substantially or have the ability to destroy a majority of the massed forces (two-thirds in this scenario) at distances as close as 2-3 km from the defender's force.

A dispersed formation causes a slower presentation rate. There is also an increase in the elapsed time of a battle when a formation is dispersed.

This further implies that if mass cannot be offset by increases in blue forces or blue weapon lethality, then methods to reduce the attacker's velocity should be sought.

If two blue companies instead of one blue company is needed to defend against an attacker, doubling the blue company's direct fire capabilities may not compensate for the need for additional forces, as seen in Figs. 5 and 6. This indicates that a technological advantage of a combat system may not substitute for numerical shortages of combat systems.

The general observation from this analysis is that mass and momentum give an attacking force a significant advantage. This advantage is strong and is not easily offset by increasing blue's combat power. If red forces are able to present their forces in densely packed formations they may be able to accept high losses from area weapons and still be successful.

VII. RECOMMENDATIONS FOR FURTHER STUDY

see "Calling the Reserves" N-16454,725

A. It appears this type of analysis could be extended to examine time of the attack and velocity of the attacking forces in order to analyze momentum as a function of both mass and velocity. The sensitivity of velocity could be examined by varying the attacker's velocity through a wide range (3 km/hr to 50 km/hr).

B. The conventional capabilities (reload rate, PK, mobility, etc.) of the attackers and defenders should be varied through a wide range of values to examine the advantages of each type of system against a massed attacker.

C. The contribution of counter-mobility tactics (use of obstacles and barriers) also needs to be addressed. Use of tactical area weapons should also be examined when used with obstacles.

RED MASSED FORMATION OF 100 TANKS (s = 25m, S = 100m)
BLUE DEFENDING WITH ONE COMPANY
(Figure 1a)

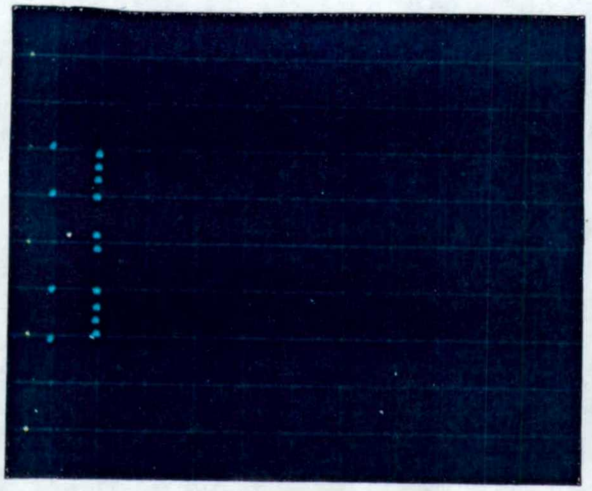


FIG. 1
BLUE INITIAL PSNS
500m GRID

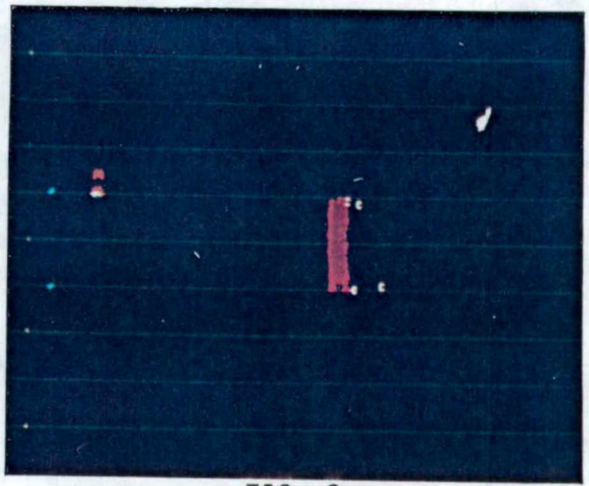


FIG. 2
BLUE VIEW - WHITE "c"
INDICATE CASUALTIES TAKEN
FROM BLUE HAW SYSTEMS

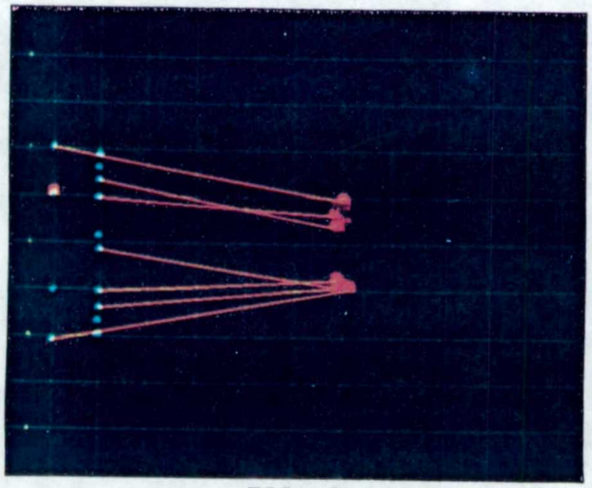


FIG. 3
BLUE HAWS & TANKS ENGAGE
RED

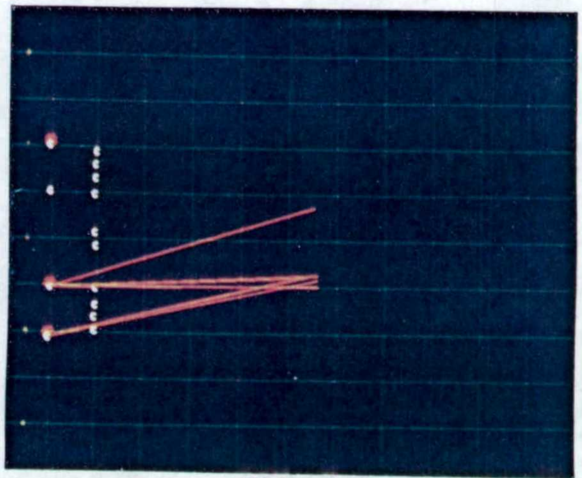


FIG. 4
BLUE REMAINING HAWS
RECEIVE RED TANK FIRE

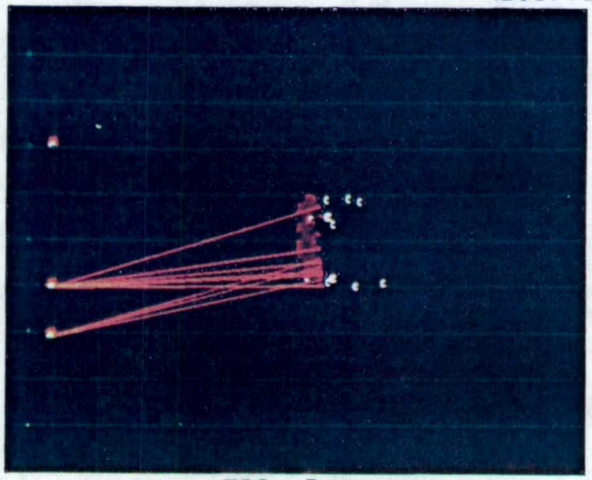


FIG. 5
RED VIEW AS BATTLE ENDS

RED FORMATION 10 LINES OF 10 TANKS
EACH (s = 100m) WITH LINES 2000m APART (S = 2000m)
BLUE DEFENDING WITH ONE COMPANY (FIG. 1c)

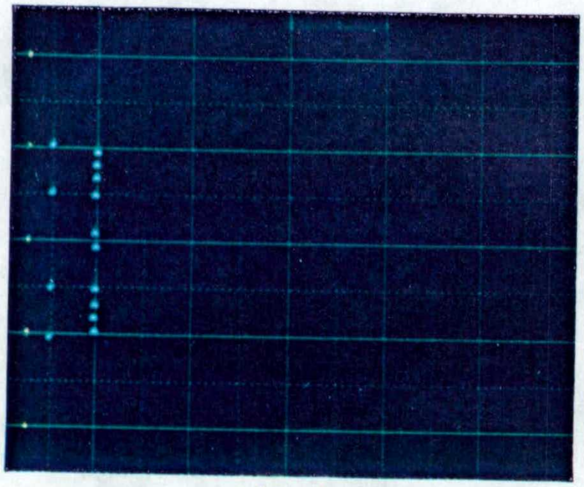


FIG. 1
BLUE INITIAL PSNS

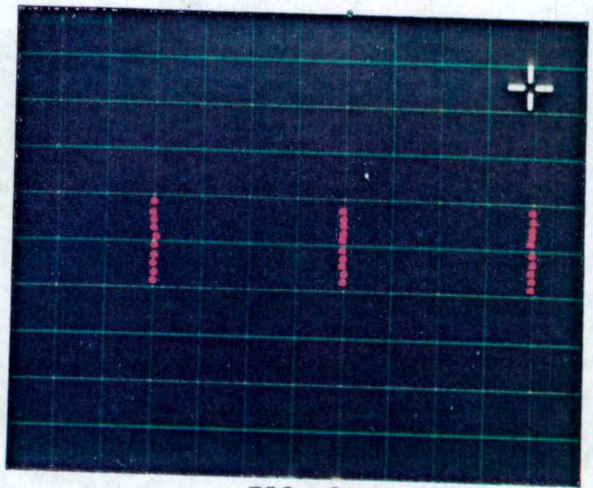


FIG. 2
RED FORCES DISPERSED
500m GRID

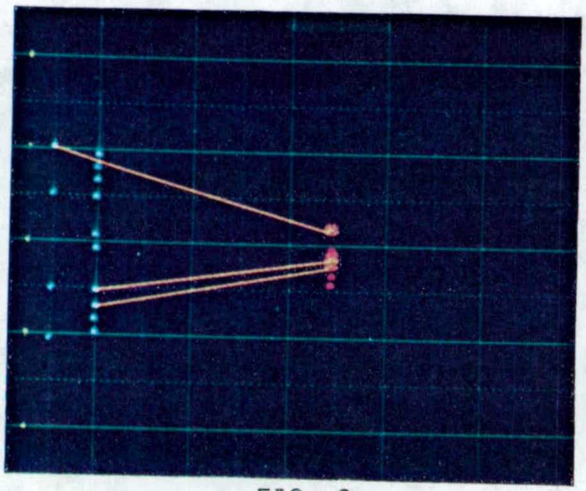


FIG. 3
BLUE HAW AND TANKS
ENGAGE FIRST RED LINE

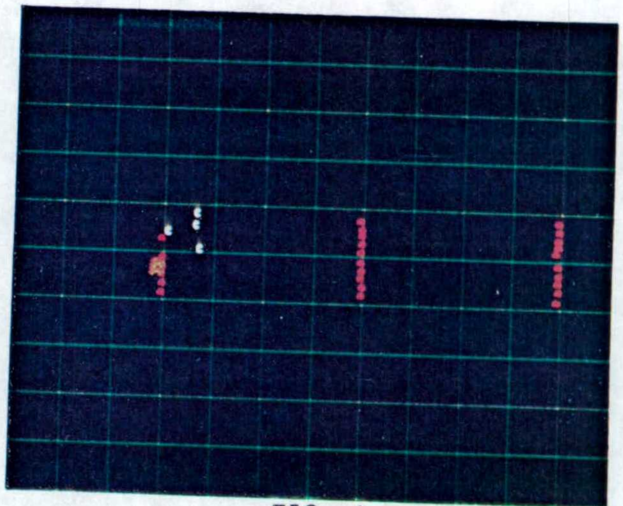


FIG. 4
RED LOSSES TO HAW
BEFORE OPENING FIRE

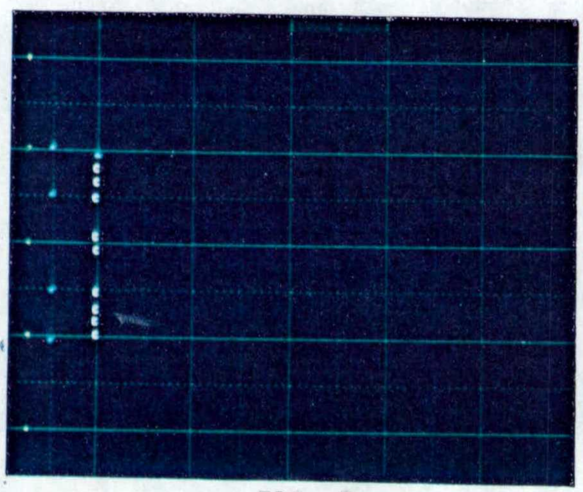


FIG. 5
END OF BATTLE BLUE

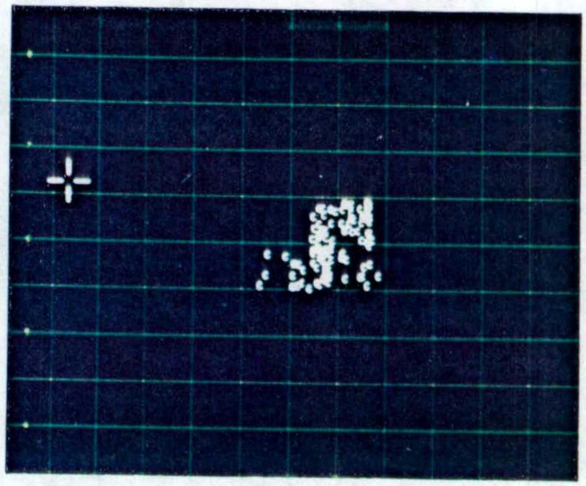


FIG. 6
END OF RED 100 CASUALTIES

RED MASSED FORMATION (s = 25, S = 100)
REDUCED TO 54 TANKS BY NUCLEAR MUNITION.
BLUE DEFENDING WITH ONE COMPANY (FIG. 8a)

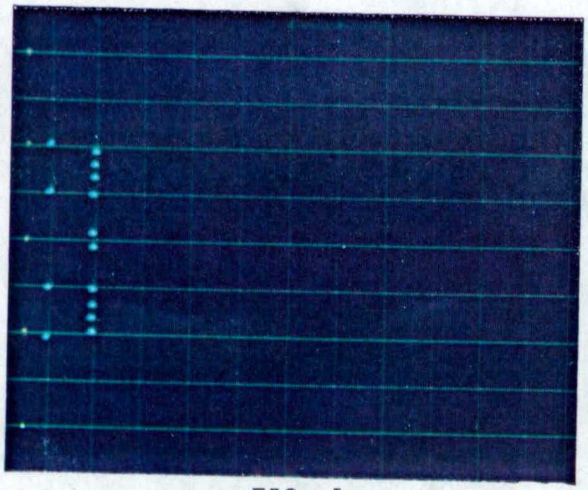


FIG. 1
BLUE INITIAL PSNS
500m GRID

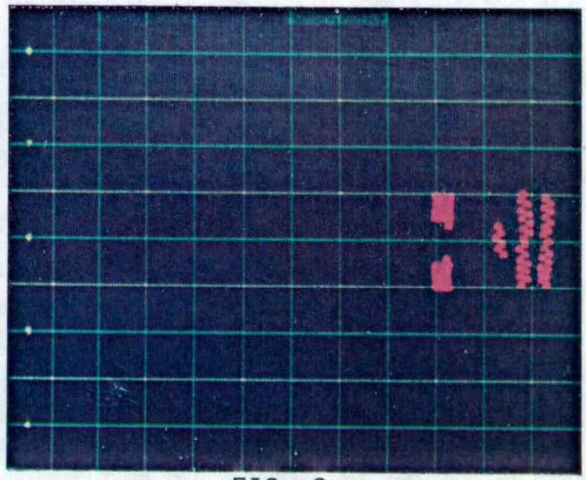


FIG. 2
RED FORCE WITH NUCLEAR
CASUALTIES REMOVED TO
RIGHT EDGE OF SCREEN

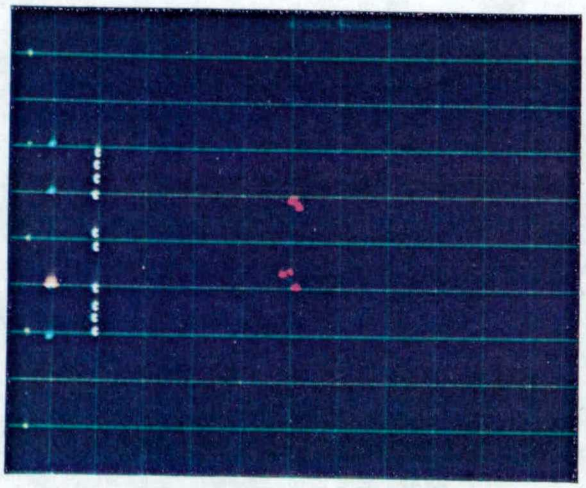


FIG. 3
BLUE VIEW AS LAST TANKS
DESTROYED - 4 HAW REMAIN

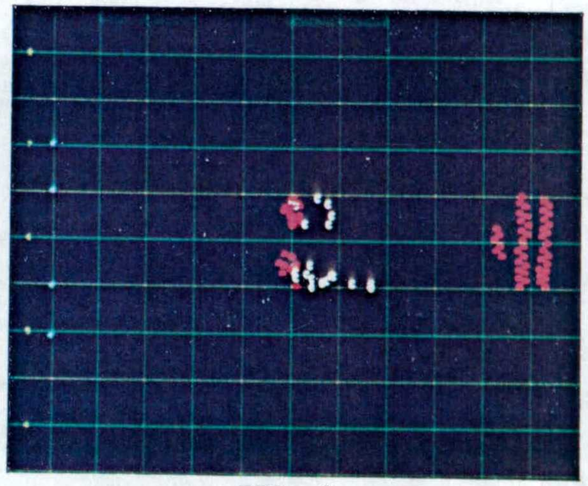


FIG. 4
RED VIEW - SAME THING AS
FIG. 3. RED LOSSES NOTED

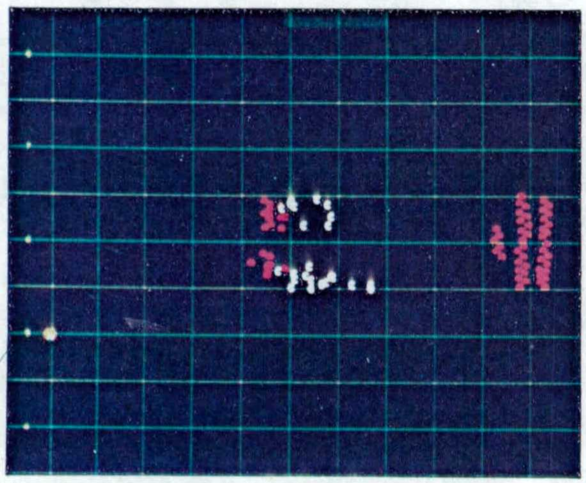


FIG. 5
RED VIEW BATTLE ENDS

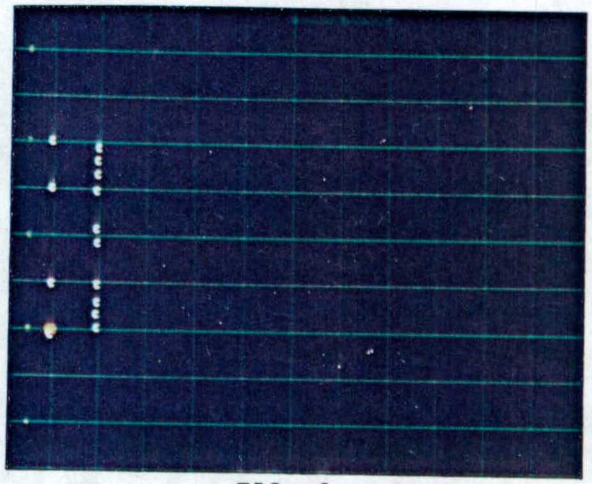


FIG. 6
BLUE VIEW LAST HAW KILLED

One Blue Company vs. Three Red Formations
Figure 1

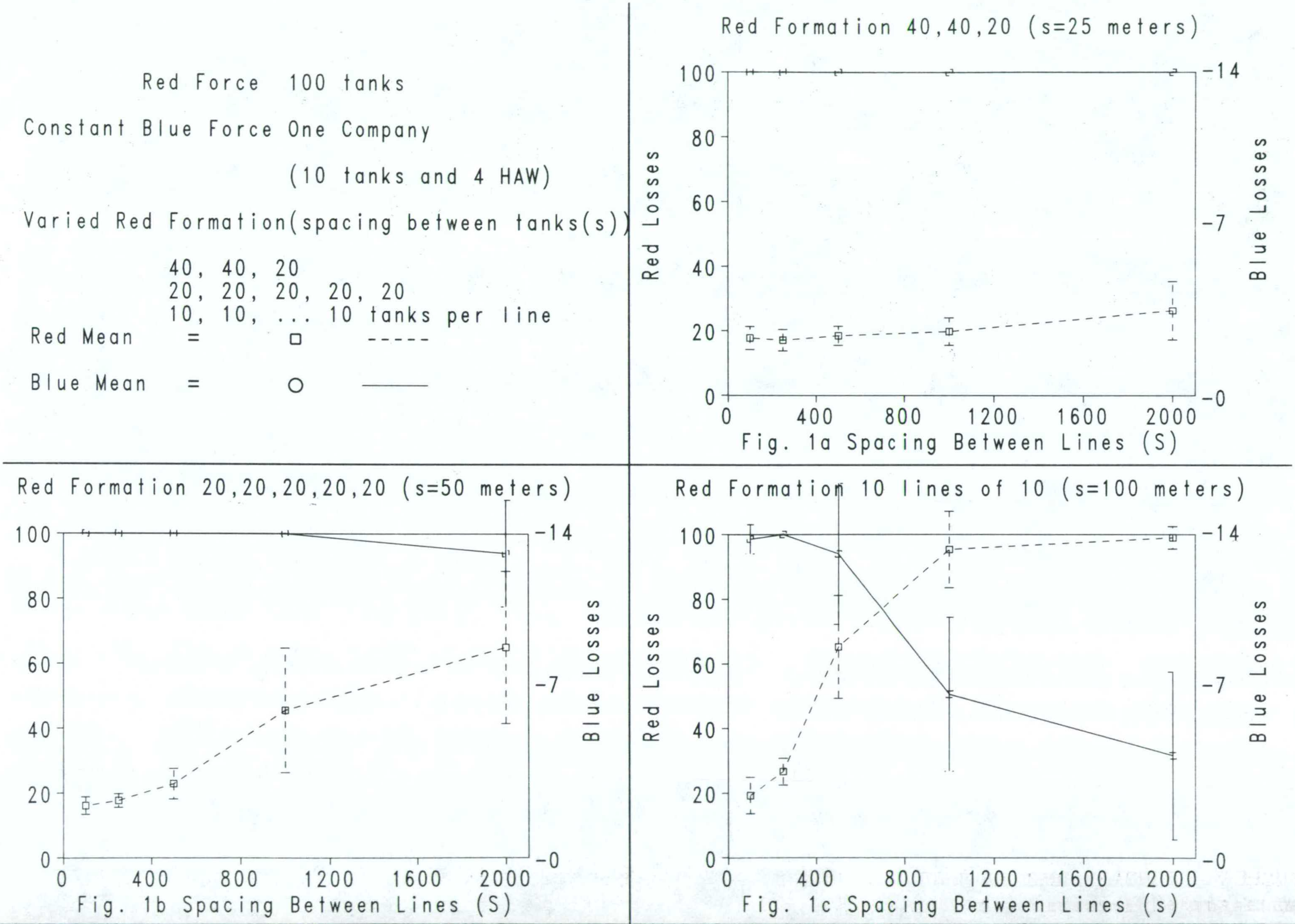


Figure 2 - Time Duration of Battle
One Blue Company vs. Three Red Formations

Red Force 100 tanks

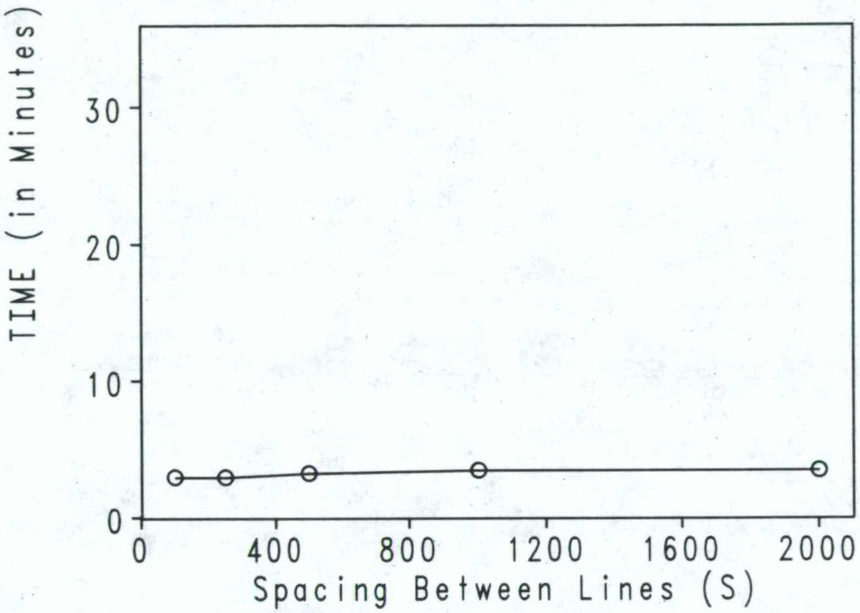
Constant Blue Force One Company

(10 tanks and 4 HAW)

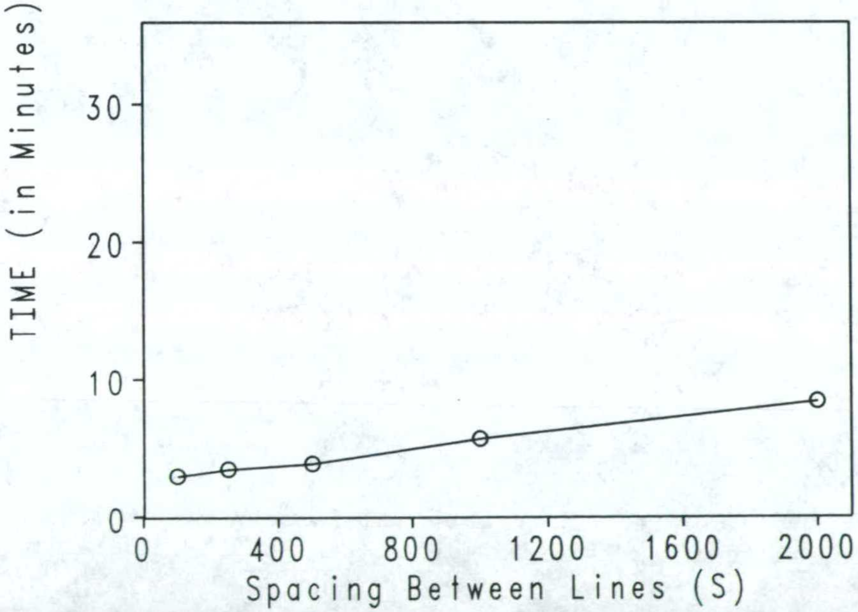
Varied Red Formation(spacing between tanks(s))

40, 40, 20
20, 20, 20, 20, 20
10, 10, ... 10 tanks per line

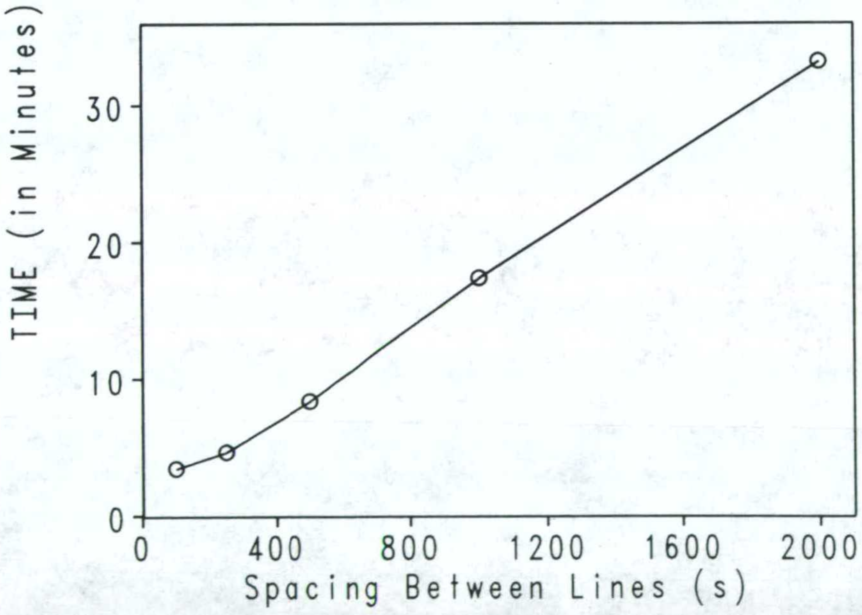
Red Formation 40,40,20 (s=25 meters)



Red Formation 20,20,20,20,20 (s=50 meters)



Red Formation 10 lines of 10 (s=100 meters)



Massed Red vs. 1, 2 and 3 Blue Companies
Figure 3

Red Force 100 tanks

Blue Force 1, 2 and 3 companies
(10 tanks - 4 HAW per co.)

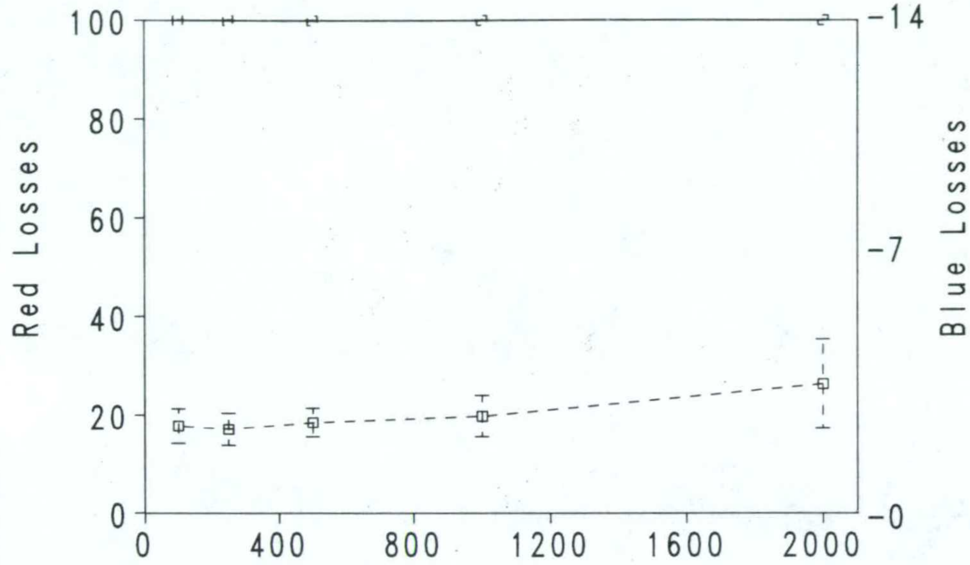
Red Attack Formation:
40, 40, 20 tanks on each line (1KM)
Intra-line spacing 25 meters (s)

Interline spacing = S varied 100, 250, 500, 1000 and 2000 m

Red Mean = □ -----

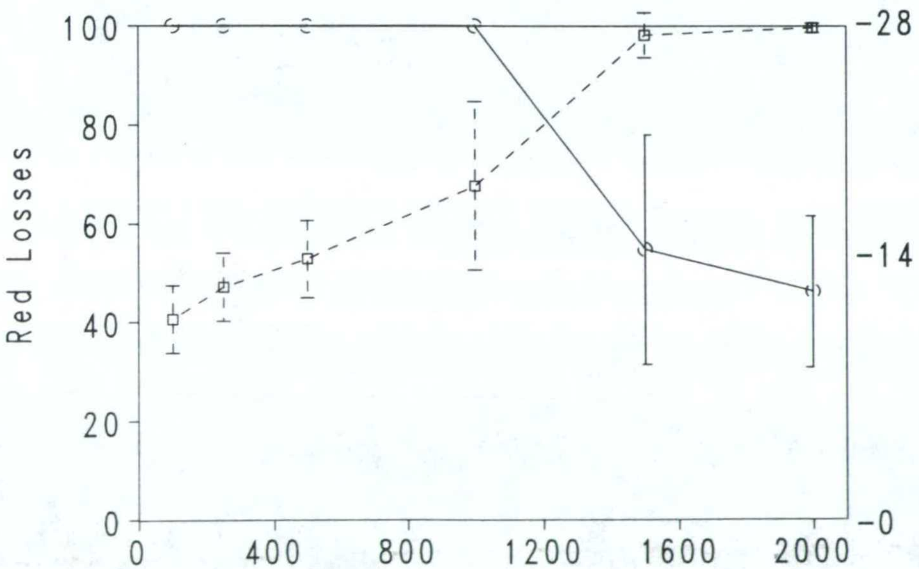
Blue Mean = ○ ———

1 Company



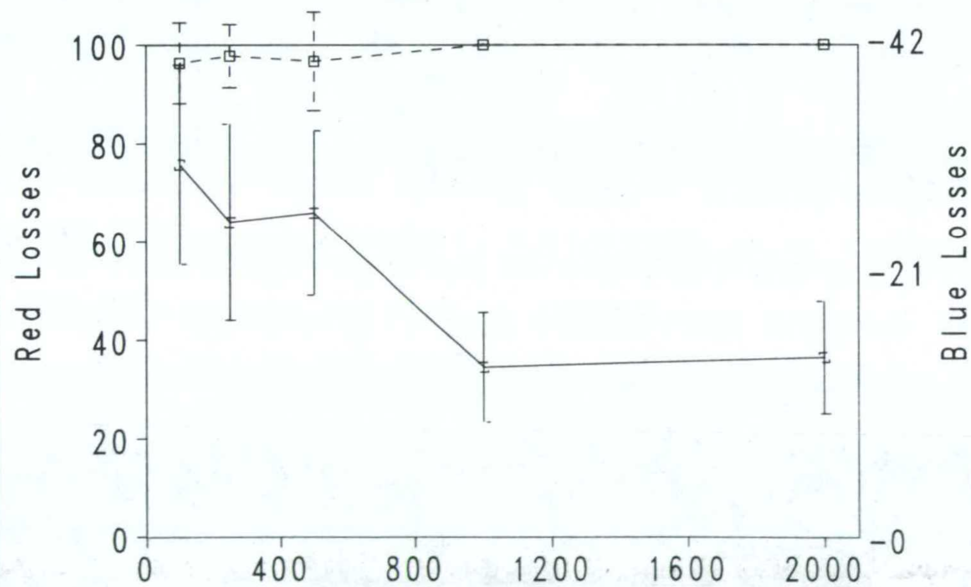
(FIG. 3a) Spacing Between Lines (S) meters

2 Companies



Spacing Between Lines (S) meters (FIG. 3b)

3 Companies



(FIG. 3c) Spacing Between Lines (S) meters

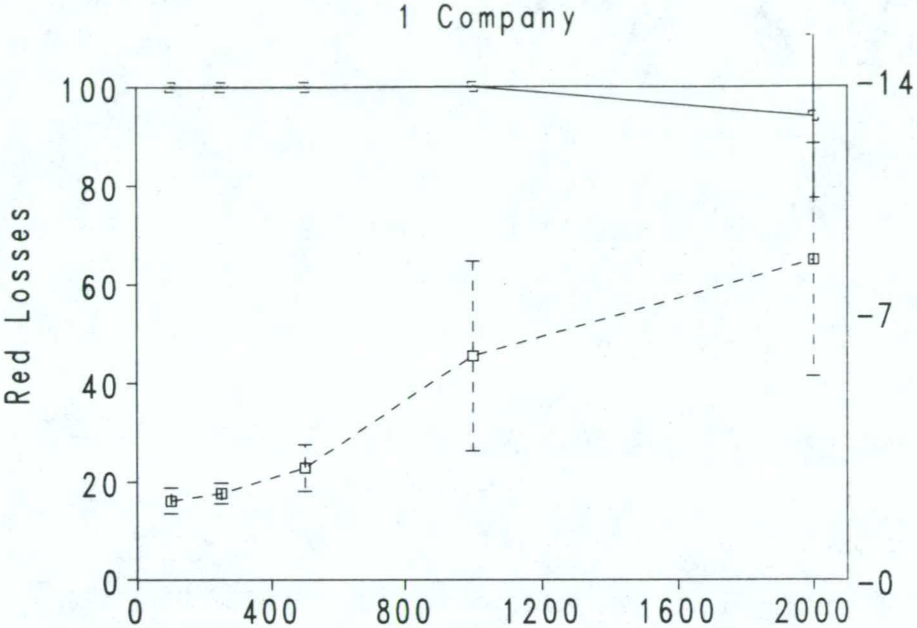
Dispersed Red vs. 1, 2 and 3 Blue Companies
Figure 4

Red Force 100 tanks
Blue Force 1, 2, and 3 companies
(10 tanks, 4 HAW per Co.)

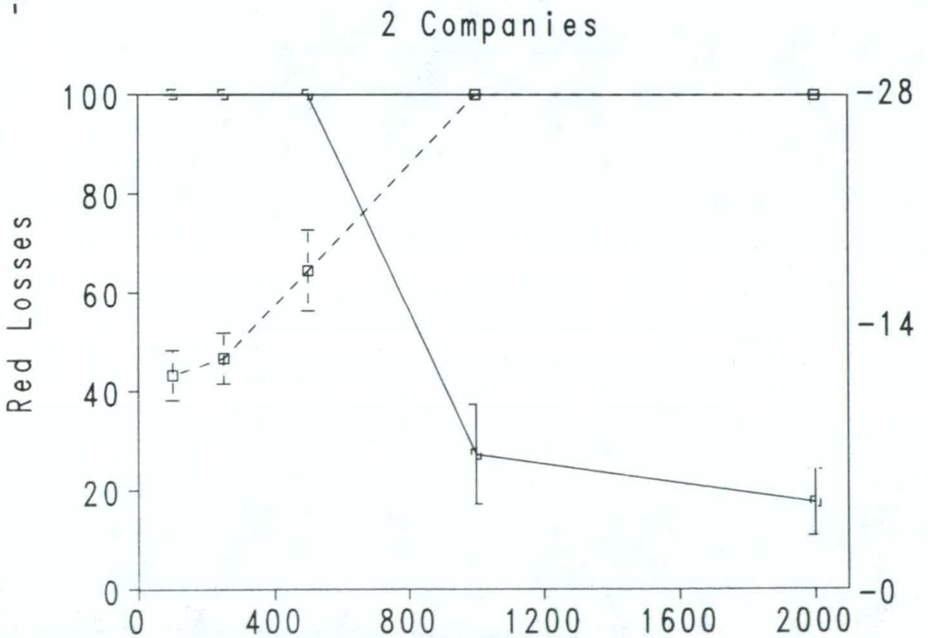
Red Attack Formation:
20, 20, 20, 20, 20 tanks on each line(1km)
intraline spacing 50 meters(s)
Interline spacing = S varied: 100, 250, 500, 1000, and 2000 meters

Red Mean = □ - - - - -

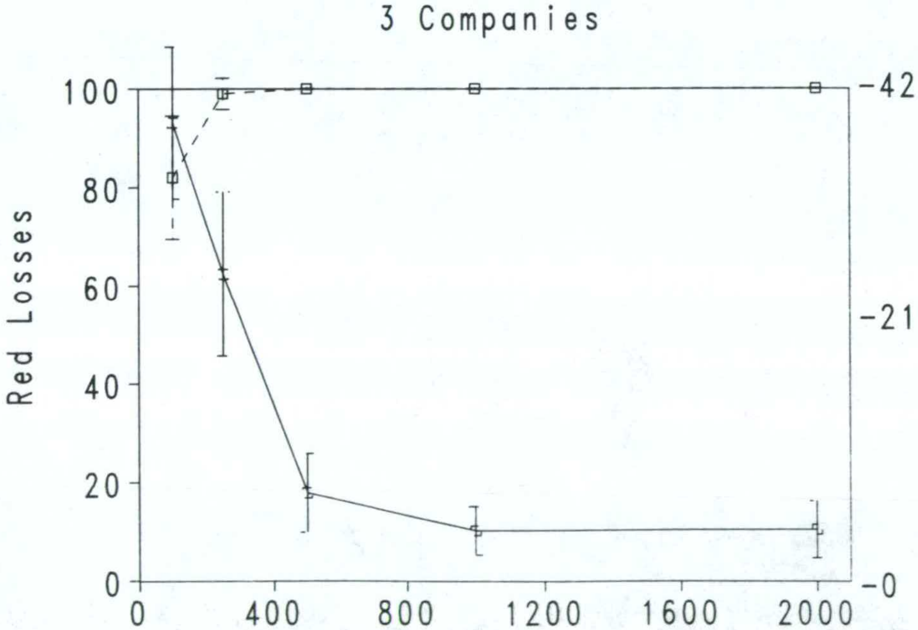
Blue Mean = ○ ———



(FIG. 4a) Spacing Between Lines (S) meters



Spacing Between Lines (S) meters (FIG. 4b)



(FIG. 4c) Spacing Between Lines (S) meters

One Blue Company (2x rate of fire) vs. Two Blue Companies
Figure 5

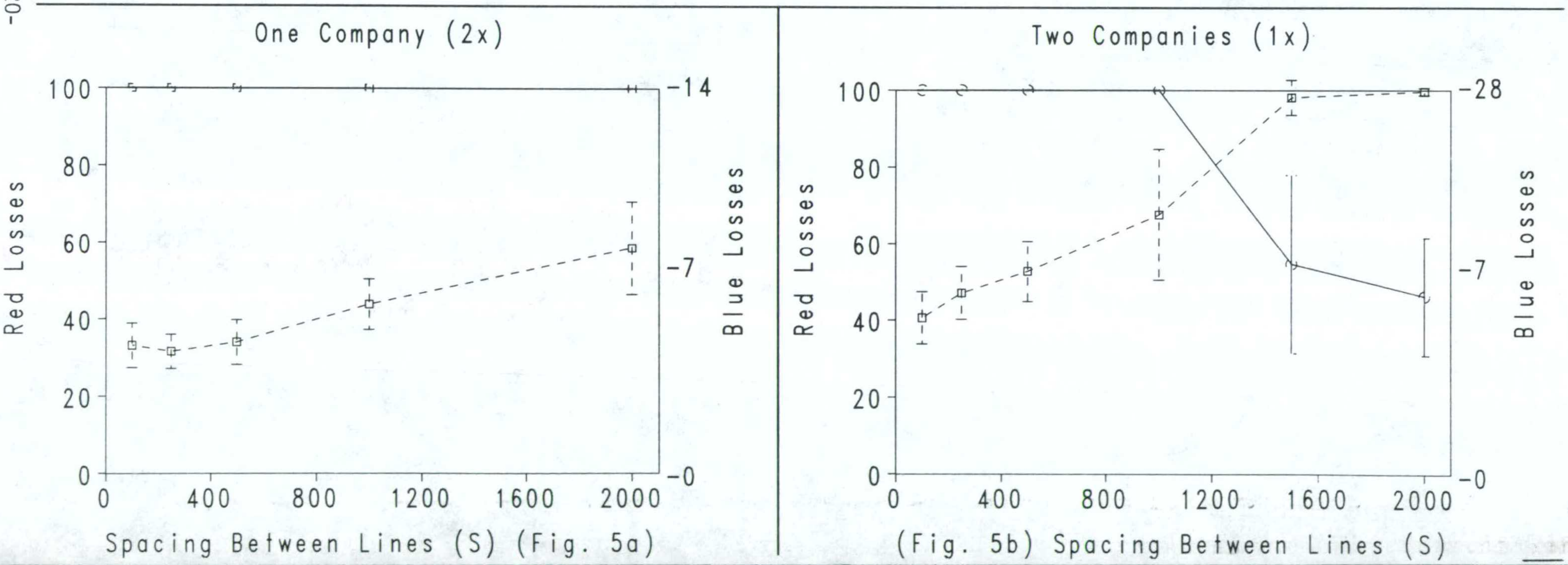
Blue Force (Fig. 5a) One Company with Double the Rate of Fire
(Fig. 5b) Two Companies with Normal Rate of Fire

Red Force 100 Tanks

Red Formation Massed 40, 40, 20 (s=25)

Red Mean = □ -----

Blue Mean = ○ ———



One Blue Company vs. Two Blue Companies (1/2 pk)
Figure 6

Blue Force (Fig. 6a) One Company with Normal Probability of Kill
(Fig. 6b) Two Companies with 1/2 the Probability of Kill

Red Massed Formation 100 Tanks s = 25 meters

Red Mean = □ -----

Blue Mean = ○ ——

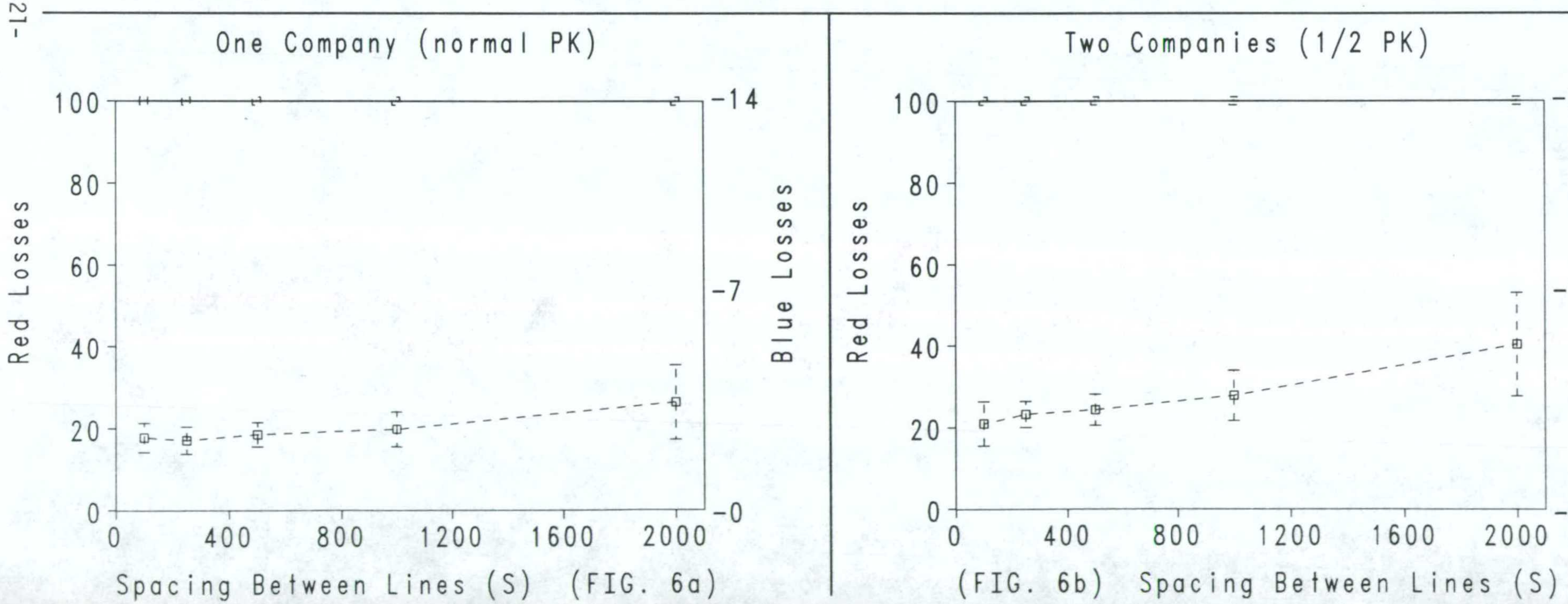


Figure 7 - Results of Reduction of Red Force
Advanced Conventional/Nuclear Munition

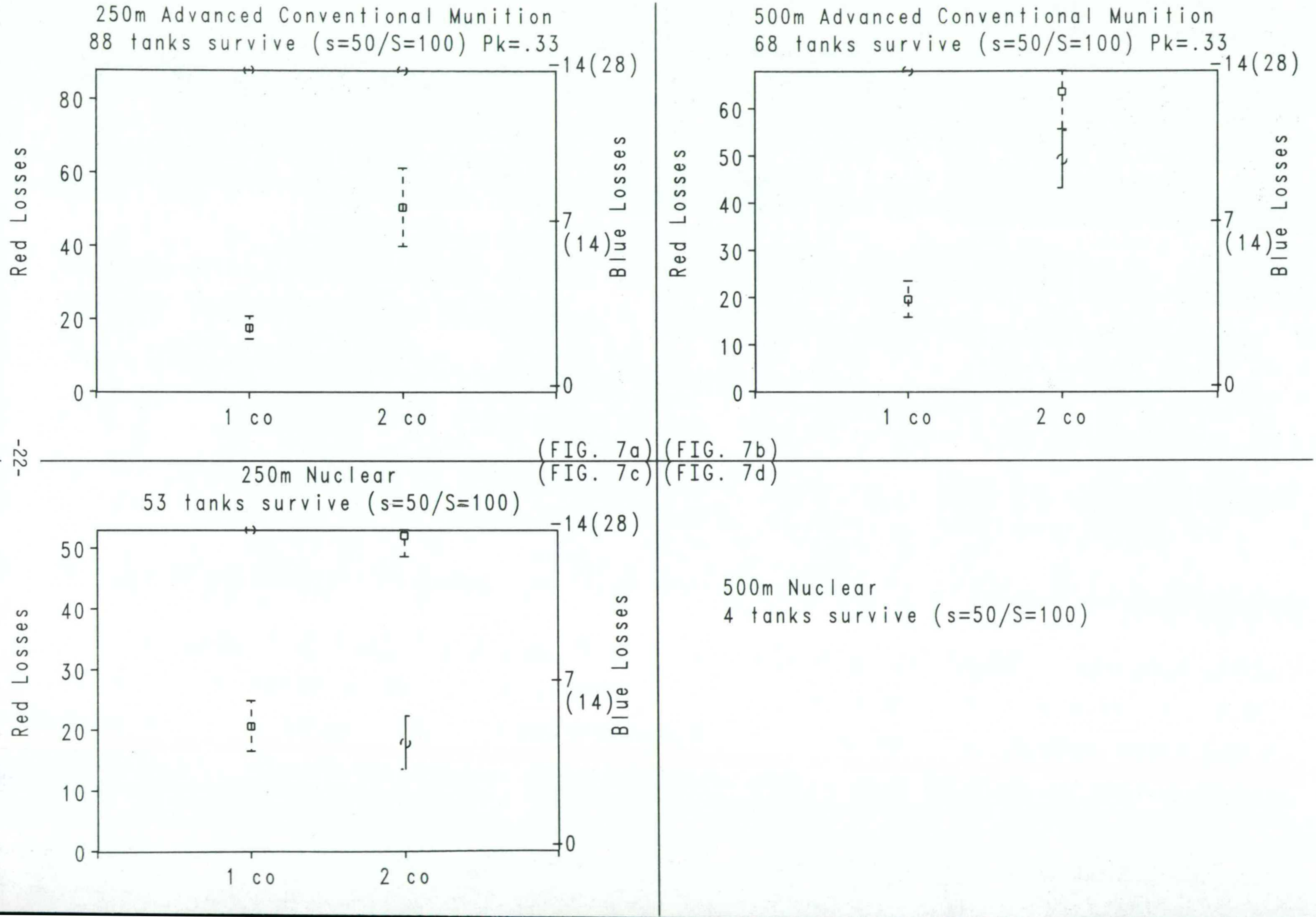
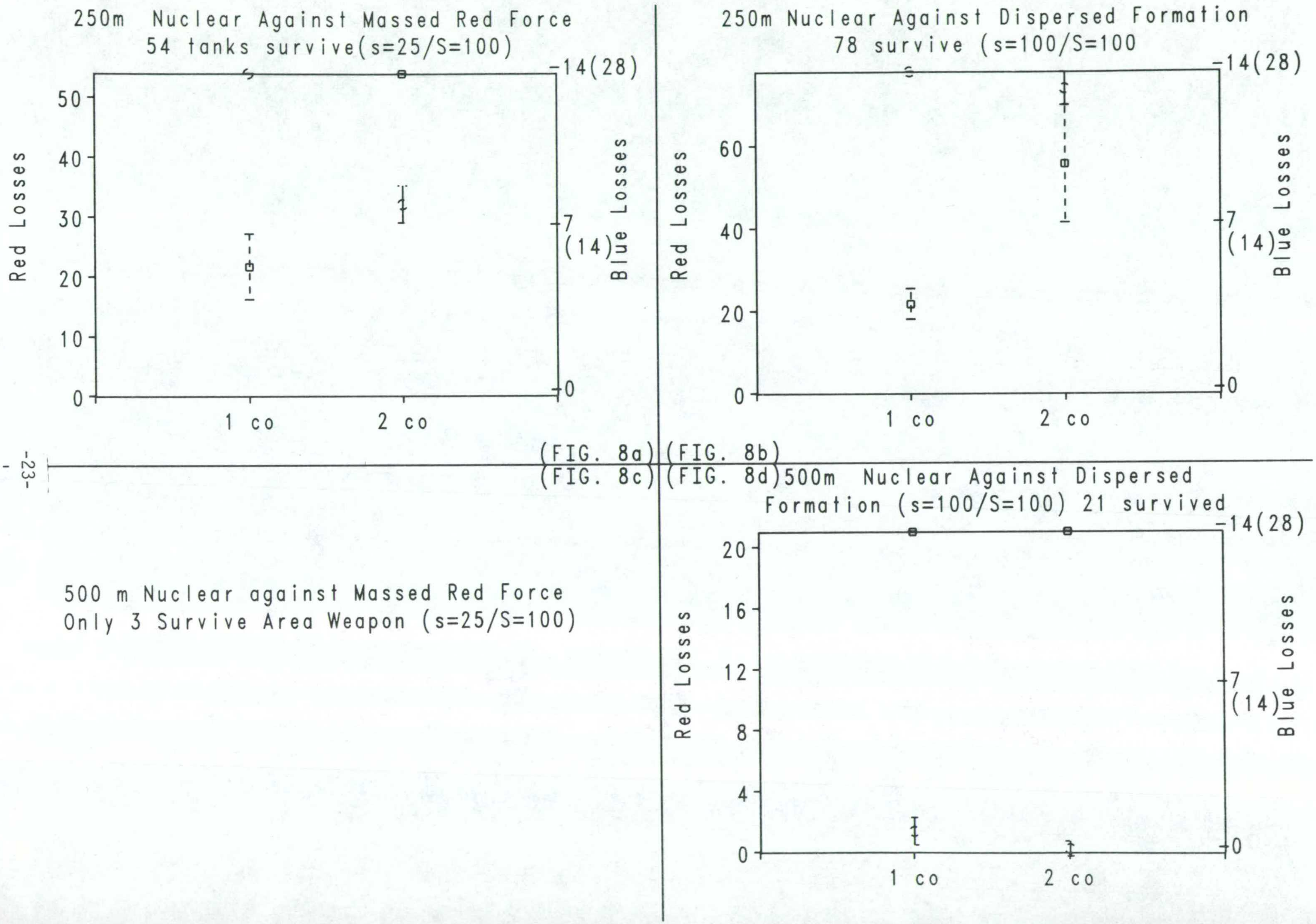


Figure 8 - Results of Reduction of Red Force
Nuclear Munition



APPENDIX A

JANUS SIMULATION

APPENDIX A
JANUS SIMULATION

JANUS is a computer simulation of battlefield conflict developed by the Lawrence Livermore National Laboratory. Extensive use of high resolution color graphics and interactivity are major characteristics of the JANUS simulation.

JANUS RUNS ON A STANDALONE MINICOMPUTER

The JANUS simulation models combat systems, the battlefield environment (terrain), and each system's interaction with other systems and their environment (acquisition, firing, movement, etc.). The model is an event-driven, stochastic simulation written in FORTRAN. A dedicated VAX 11/780 minicomputer processes the numerical calculations required for a system level simulation in near real time. The data used for attrition assessment and weapons' characteristics can be interactively reviewed and changed by the user during the simulation initialization.

JANUS IS AN EVENT-DRIVEN, STOCHASTIC SIMULATION

JANUS is an event-driven simulation which models fighting systems as entities. System characteristics of each type of system (i.e., M1 tank, TOW, helicopter) are data input by the user. Characteristics include descriptions of basic load of ammunition, size, reload rate, road velocity, and probability of kill (PK) curves. A utility exists for graphic display and interactive modification of PK as a function of range against each enemy system. Separate curves are stored for moving, stationery, and hull defilade systems.

MOVEMENT

Initialization of the simulation includes positioning of each modeled unit or groups of systems (defined here as units) interactively by players at time "zero". Players may give units movement objectives during the initialization phase. Once the initial condition of the simulation has been established, the simulation clock advances in near real time. Units move across the modeled terrain at a velocity computed

by the mobility module. A ground unit movement is dependent on the slope of the terrain, presence of trees or buildings, and if the unit is engaged in direct fire. The frequency of computation of a unit's discrete movements are dependent on unit velocity. Fast movers are scheduled to be updated as often as one second intervals and slow moving vehicles on rugged terrain may be updated only every 20 seconds. Unit positions are stored in UTM grid coordinates.

LINE-OF-SIGHT, ACQUISITION, AND ENGAGEMENT

The JANUS model iteratively computes line-of-sight between each unit and all enemy units. The three-dimensional terrain model, including clouds, trees, and buildings, may block intervisibility between units. Once line-of-sight is established to an enemy unit, the probability of acquisition is calculated. Depending on the random number drawn at occurance of line-of-sight, the unit will acquire the enemy after a delay for the acquisition process. Upon acquisition, if the system is able to engage the enemy, a shot is fired. After a time delay for time-of-flight the effect of the shot is assessed. A random number is compared to the probability-of-kill (PK) curve to determine if one enemy system is killed. As time advances, units continue to engage each other until one unit is killed, line-of-sight is broken, or no ammunition remains.

HIGH RESOLUTION GRAPHICS ON "N" VIEWS

JANUS allows the user to make tactical or doctrinal decisions relating to fire planning and maneuver in a competitive multisided environment. This is achieved by using high resolution color graphics to display the battle situation as known in near-real time and allowing people to become part of the simulation by using interactive graphics devices to plan movement and firing. This provides an opportunity to study the process of decision making and command and control when decisions are of necessity based on incomplete information.

The JANUS model is configured to use n-views of the battlefield, where n may be 1, 2, 3, or more interactive color graphics workstations in separate rooms each with its own view of the battle. Tanks, helicopters, artillery, and other fighting systems are assigned or "belong" to distinct views and consequently are controlled by the "commander" of those forces. Each of the fighting forces may be assigned varying numbers of views - depending on the scenario to be wargamed. For example, if four views (workstations) are physically available, then the user may assign either (1) two views to each side, or (2) three views to one side and one view to the opposing side. The use of n-views and user allocation of force and terrain provide in JANUS a flexibility to model a wide variety of battle scenarios. A small company size force defending against an enemy battalion may be modeled or a defending division size force with brigade commanders on separate terrains/views may fight an attacking force of one or two divisions.

SCENARIO CREATION

A software utility allows a user to specify the force structure of enemy and friendly units. The user specifies the number of units, the type of each unit (tank, tow, etc.), and the number of elements (systems) initially in each type unit (5 tanks in a platoon). The systems characteristics are also defined: Spacing between elements, size of system, height of observer above ground, maximum visibility, maximum firing range, basic load, road velocity, and hardness to neutron and gamma radiation. Probability of kill curves are associated with each type unit.

DIGITIZED TERRAIN

JANUS uses digitized terrain elevations as provided by the Defense Mapping Agency. A utility allows the contour lines to be drawn to graphically represent a two-dimensional display of the three-dimensional terrain model. Using a graph tablet; trees, cities, rivers, and roads may be added to the terrain. The terrain file may then be used with the scenario of forces for a simulation. The terrain may be used in the resolution available, normally 12.5 to 100 meter grids.

WARGAME PHASES

A typical gaming application of JANUS follows:

(1) The user (an analyst) selects a scenario with specific numbers and types of units on each side, and the terrain scale and location for the simulated battle.

A plan is developed to accomplish the missions assigned each force. Rules of engagements, constraints, etc., may be imposed as conditions on the players external to the simulation.

(2) Players at each workstation position their tanks, helicopters, and other systems in initial positions on the terrain using interactive graphics to move and check the units line-of-sight (ability to observe the surrounding terrain). Movement objectives are planned to correspond to tactical plans.

(3) After all players have completed their initial plans, the simulation begins. A digital time is displayed on each view and units begin moving toward assigned objectives at a speed determined by the characteristics of the system and terrain. As enemy units are acquired within range, units begin shooting direct fire. Players assign missions for indirect fire to their artillery and missile units. The possible types of shells available are high explosive, improved conventional munitions (ICM), smoke, chemical, and nuclear. Upon impact, the immediate casualties are assessed. In the case of nuclear weapons, the terrain is modified to reflect the impact of fires and blowdown of trees or buildings.

(4) During the simulation an observer or controller station is able to monitor all the views at each of the workstations. The controller critically observes the battle, collects data and takes photographs of the views at appropriate events and time intervals, and determines the end time of the simulation.

(5) After termination of the simulation, an analyst examines the data (each shot fired is recorded with details as to range, target, posture, etc.) and the photographs (showing the movement of the forces), and also talks to the players (commanders) to gain insights into the driving factors in the outcome. All graphics displays may be recorded for playback.

There is a wide variety of possible applications of the JANUS simulation. The characteristics of a weapon system (tank, missile, etc.) may be changed (more lethal or greater range) and the outcomes of the simulation compared. Another application is to allow planners to explore the use of a new weapon system or new organization. Perhaps most importantly, the overall tactical decisions for the maneuver of the force and the coordination with other commanders may be examined and evaluated.

SIMULATION PHASES

JANUS may be used in a "non-wargaming" mode. If the purpose of an analysis is to examine a parameter that may be varied while holding the tactical plans constant, JANUS can be run in batch mode.

A typical simulation application of JANUS follows:

1. The user selects a specific scenario, stores short term movement objectives, and stores the initial conditions.
2. The scenario is run in batch mode a specific number of times. The simulation halts each time when a specific, well-defined condition is met (i.e., all units on one side are killed or a defensive line is broken). A distribution of possible outcomes is collected by varying the initial random number seed.
3. A single parameter may be varied in the initial scenario. For example, the maximum range <u>or</u> the reload rate of a tank may be increased. The scenario is again run in batch mode without human interaction to measure the delta in the new distribution of outcomes.

4. Analysis can now be applied to the audit trail in the output data to identify how the battle was affected over time and to quantify the significance of the changed parameter.

SUMMARY

A dedicated minicomputer provides adequate computational power to be responsive to real time interaction by players. Scenarios with a large number of forces typically focus the conflict on one or two key areas of the terrain. The result is that at any given time only a small fraction of the entire force is engaged in close combat. As the number of forces on each side increase, the number of possible interactions increase exponentially. The number of actual interactions (calculational load) depends more on the timing of movement, size of the units, and number of avenues of the attacking forces.

In some models, a large portion of the calculational load of a combat simulation is for the computation of the tactical decisions based on the force's mission, the enemy situation, and the terrain. JANUS does not use decision algorithms. Instead, color graphics monitors display the status of the simulation and the interactive graphic devices allow the human to interject their decisions during the processing of the simulation. Two important things happen. One, the decision logic becomes as sophisticated in its decision making as in the capability of the human "commander" and secondly, the computational workload of the complex decision process has been off-loaded to the human. This allows for further increases in force size and complexity as additional people simultaneously interact during the simulation while still maintaining the individual system resolution. The principle of war "Surprise" can be invoked, a unique feature of human participation.

Fairly significant observations are made after conducting a series of simulations with the same players. The players first become aware of the significance of their decisions and are affected by review of their tactics by controllers (observers) and themselves. Players also learn to avoid tactical errors through this simulated experience. They learn to exploit the capabilities of their force and to evaluate various options

to include the element of surprise. JANUS allows players to work together in executing their tactical plan and to coordinate their maneuver forces and firepower. The process of the development and testing of control measures is now able to be monitored and analyzed.

When an analysis is complete, the quantitative results are compared, and insights obtained from the participants are recorded based on their shared synthetic but very real experiences.

APPENDIX B

GENERAL SYSTEM CHARACTERISTICS

APPENDIX B

GENERAL SYSTEM CHARACTERISTICS

	ATGM (HAW)	BLUE TANK	RED TANK
BASIC LOAD AMMUNITION	UNLIMITED	UNLIMITED	40
ORDNANCE VELOCITY (km/sec)	0.2	1.6	1.6
MAXIMUM RANGE (km)	3.7	2.5	2.5
RELOAD TIME (sec)	18	12	18
MAXIMUM VISIBILITY (km)	4.0	3.0	3.0
SPEED (km/hr)			
SHOOTING (AVERAGE)	STATIONARY	STATIONARY	12
NOT SHOOTING	STATIONARY	STATIONARY	35
PROBABILITY OF KILL	FUNCTION OF RANGE AND TARGET POSTURE		

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